Economic Geology
Vol. 95, 2000, pp. 1-18

The Importance of Oxidized Brines for the Formation of Australian Proterozoic Stratiform Sediment-Hosted Pb-Zn (Sedex) Deposits

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Abstract

A two-fold subdivision for stratiform sediment-hosted Pb-Zn (sedimentary exhalative, sedex) deposits is proposed, based on fundamental differences in the chemistry of the mineralizing brines. The type of sedimentary basin from which the ore fluids are derived, and the lithologies contained within the basin, control these differences in fluid chemistry.

The two discrete brine types capable of transporting Zn and Pb are oxidized brines and reduced, acidic brines. McArthur-type deposits (e.g., McArthur River, Mount Isa, Hilton) precipitate from oxidized (SO_4^{2-}-predominant), acidic to near-neutral brines that evolve from sedimentary basins dominated by carbonates, evaporites, and hematitic sandstones and shales. Selwyn-type deposits (e.g., Sullivan, Rammelsberg, sedex deposits of the Selwyn basin) precipitate from acidic, reduced (H_2S-predominant) connate brines that evolved in reduced siliciclastic and shale basins.

Temperature decrease and dilution (fluid mixing), addition of H_2S, and pH increase can all be effective depositional processes for Zn and Pb from reduced (Selwyn-type) brines. In contrast, sulfate reduction and/or addition of H_2S (via fluid mixing or interaction with earlier formed pyrite) may be the important processes for sphalerite and galena deposition from oxidized (McArthur-type) brines. McArthur-type sedex deposits are intimately associated with siderite or ferroan carbonate alteration halos and most likely precipitate from lower temperature brines than Selwyn-type deposits.

The redox state of the mineralized brines (sulfate or sulfide predominant) is important for controlling minor element associations in the two classes of sedex deposits. Weakly acidic to weakly alkaline oxidized brines can precipitate siderite but are incapable of carrying significant gold, tin, and barium in solution, and as such, McArthur-type deposits do not contain anomalous concentrations of these elements. Reduced, acid brines can carry high concentrations of barium, explaining the common association with barite in these deposits. If reduced sulfur concentrations were sufficient in the mineralizing brines, individual Selwyn-type deposits may contain anomalous or ore-grade gold. If the brines were highly reduced (pyrrhotite-stable), they may have carried high concentrations of tin (e.g., Sullivan). The lack of sulfide-bearing feeder systems in McArthur-type deposits and their common occurrence in Selwyn-type deposits probably also relate to the redox state of the brines.

From a mineral exploration perspective, oxidized sedimentary brines are more likely to produce large tonnage Zn-Pb-Ag deposits that have siderite or ankerite alteration halos and commonly lack barite lenses and vent complexes. By contrast, deposits that form in reduced siliciclastic and shale-dominated basins are more likely to be lower tonnage and to contain barite, vent complexes and may have minor gold or tin credits.